Market Opportunity Summary

Soy-Based Thermoset Plastics

UNITED SOYBEAN BOARD

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The Product

Building materials, components of foam insulation and molded mill work; parts for cars, trucks, trains, planes, tractors, tractor trailers and recreational vehicles; furniture, mattresses, carpet pads and carpet binders; insulation for coolers, water heaters and vending machines; packaging and pallets; materials for ships, boats and flotation devices; industrial insulation and sealing; shoes and boots — all are end uses for soy-based polyol and polyester thermoset plastics.

Market Size and Value: Urethane

Of all the industrial markets for soy polyol, urethane foams, binders, coatings, adhesives and sealants hold the greatest potential. Annual North American product demand for polyols represents 3 billion pounds, with a conservative estimate for soy oil of about 800 million pounds, or 80 million bushels of soybeans. Specifically, priority markets for soy-based polyurethane are (in millions of pounds of product):

Product	Polyurethane market total (mil. lb.)	Possible soy polyol (mil. lb.)
Foam	2,600	700
Polyurethane binders & CAS	400	100
Total	3,000	800

The North American market represents only a third of the global market for polyurethanes and the ultimate potential for soy utilization could be tripled from the 800-million-pound level.

Market Segments

There are six market segments for polyurethane that can be classified as priorities for soy-based products. They include:

1) Construction. Residential and nonresidential buildings, refrigerated buildings, walk-in coolers, molded millwork, laminated insulated board block, block insulation, insulated doors and metal panels

2) Transportation. Automotive and farm equipment

3) Carpet. Flexible foam and fiber binders

4) Appliances. Household appliances, reach-in coolers, recreational coolers, vending machines and water heaters

5) Packaging. Foam packaging and pallets

6) Tanks and pipes. Industrial insulation and sealing

Penetration of the six priority market segments is estimated to be (in millions of pounds of products):

Segment	Market size (mil. lb.)	Soy products (mil. lb.)
Construction	455	200
Transportation	635	200
Carpet	420	100
Appliances (insulation)	110	25
Tanks & pipes	65	10
Packaging	110	25
Total	2,380	560

The Construction Market: Rigid Foam

The construction market segment can be divided in several different subsegments, as named above. Rigid foam normally has two functions: insulation (mainly in the appliance, residential and industrial applications) and structural integrity. The foam is made from low-cost, highly functional polyols and isocyanates with many additives to adjust the formulation for specific end-use properties. Soy-oil polyols could compete as a reactive component in quantities of up to 50 percent.

Relative Economics

To have a driving force for market entry, soy materials must lower the cost of urethane products. Soy polyols and soy flour can reduce the cost of the foam formulation and be factors for greater use. Soy flour costs 20 to 25 cents per pound. Soy oil costs 18 to 25 cents per pound. This compares with:

Product	Price
Isocyanates	70–80 cents / lb.
Petro Polyols	50–70 cents / lb.

Replacement Potential

Rigid polyurethane foam always has been formulated from the lower cost isocyanates and polyols because of the competitive nature of the industry. Because manufacturers typically use the least expensive materials available, any additive that can lower the cost of a formulation without affecting properties will readily be accepted.

Urethane Soy Systems Company, Inc., of Princeton, Ill., has developed a series of soy-based polyols that are being commercially utilized in urethane formulations.

Market Size and Value: Plastic Composites

The use of fiber-reinforced composites (thermoset) was projected to reach a volume of 3 billion pounds at year-end 2001. Assuming total replacement of all reactive thermoset resins (half a billion pounds in 2005), the soy product usage would represent 50 million bushels of soybeans. The thermoset market is forecast to grow at 2 percent annually over the next four years. Major markets for thermoset composites are transportation, construction and marine, representing 63 percent of the total consumption.

Projected Time to Market Entry

Fiberglass-reinforced composites molded into several shapes via Atmospheric Pressure Molding (APM) have been introduced to a farm implement manufacturer. The molded parts are being evaluated as possible replacements for unsaturated thermoset polyester composites. The program has been delayed several times and remains on hold until the interested party determines its potential.

A collaborative effort has led to a commercial introduction of soy-derived composite products. Collaborators are Ashland Chemical Company (resin), The Budd Company (sheet molding compound), Ashley Industrial Molding (molded parts), Deere & Company (buyer) and the United Soybean Board. The result is a series of molded parts for the Model 2002 John Deere Harvester™ combine, introduced in August 2001.

The basic process consists of a soy-based polyester resin that is converted into sheet molding compound using industry accepted techniques and meeting Deere & Company specifications. More than 285 pounds of soy composite are installed on each combine. Acceptance and growth of the program will depend on orders received from farmers.

Ashland and its collaborators intend to expand the technology into other markets, including construction and transportation.

Faster reaction times mean more versatility in molding methods and in final applications. Higher productivity through compression molding, injection molding and pultrusion are being examined through potential industrial partners.

Meanwhile, basic benchmark research continues on soy oil to improve adaptability to key resin manufacturing steps that are efficient and economical. Interfacing with other composite raw material suppliers is now important so that optimal cure conditions and mechanical properties are obtained. Fiber producers, monomer suppliers and additive suppliers must be brought into the program to provide technical support. Rulings by certain regulatory agencies should be expected (TOSCA, EPA and state agencies).

Issues Affecting Commercial Success

The critical issues for soy in the composite plastics market are not yet determined. For new generations of soy resins to be introduced, one or more resin producers must accept the challenge of incorporating a new raw material.

Market Size and Value: Agricultural Films

Agricultural film use consists mainly of low-density polyethylene (LDPE) mulch film for growing row-crop vegetables and fruits. Film mulching promotes early production by raising soil temperatures; conserving moisture and fertilizer; and inhibiting weed growth, fungus infection and insect infestation.

Mulching practices have enhanced crop yields globally and caused plastic film use to expand rapidly since the 1950s. U.S. mulch film use is 83 to 250 million pounds per year; total world demand is about 1.3 billion.

Mulching or fumigating with typical 1.25-mil (.00125-inch-thick) LDPE film requires about 240 pounds of film per acre. Although current known mulch film use is 1.3 billion pounds, the calculated world market requirement is 2.4 billion pounds, based on reported levels of global mulching.

Rising removal and waste disposal costs of non-compostable LDPE films offers an impetus for a biodegradable/compostable product. Thus, a degradable/compostable soy protein film product is a plastic market segment opportunity. However, no

economical systems have yet been developed. Success is dependent on the development and commercial compounding of resin formulations that will provide the competitive economics, performance properties and process rates, which research to date has shown to be a difficult task.

Market Segments

Within the eight U.S. agricultural film market segments, three offer the greatest need and growth opportunities for a soy-plastic product:

Application	Million lb.
Mulch film	80
Fumigation film	15
Degradable mulch film	3
Total	98

Physical Properties

Potential product research projects include polymer modification to achieve:

- Film gauge of 1.5 mils or less
- High elasticity
- Pesticide resistance
- Semi-moisture resistance
- Ultraviolet (UV) stability
- Variable biodegradation at controlled intervals:
  - mulching – 90, 120, 150 and 180 days
  - fumigation – 5 days

Introduction of a biodegradable / compostable mulch film will create a significant opportunity to replace existing LDPE-type films. It will also create new market demand in areas where film-waste-disposal problems have limited expansion of mulch film use.

Relative Economics

Making soy-based mulch films economically competitive is a major challenge.

Soy protein raw material costs in the isolate and concentrate forms are high, and commercial LDPE mulch film pricing is relatively low:

Product	Price
Soy isolate	$0.90–$1.20 / lb.
Soy concentrate	$0.50–$0.80 / lb.
Soy flour	$0.20–$0.25 / lb.

Commercial Mulch Film	Price
LDPE smooth, standard film, 1.25–1.5 mil	$0.60-$0.65 / lb.
Specialty LDPE films	$0.72-$0.75 / lb.
HDPE , 0.6–0.7 mil	$0.75 / lb.

Removal and disposal of mulch film offers an impetus for a biodegradable / compostable product. One source estimates the cost of removal and disposal at up to $125 per acre.

A 20 to 30 percent premium may be possible if mulch film removal and disposal is not required. If so, the projected cost for the soybean mulch film would be 72 to 85 cents per pound.

Replacement Potential

The need for a truly biodegradable mulch film is widely recognized among the world horticulture and plasticulture communities. The market potential for a soy-based polymer film for mulch and fumigation in the United States is 98 to 250 million pounds. The market opportunity outside the United States is far greater, at 1.13 billion pounds.